Chapter 3
Natural Gas

In the IEO2010 Reference case, natural gas consumption in non-OECD countries grows about three times as fast as in OECD countries. Non-OECD production increases account for 89 percent of the growth in world production from 2007 to 2035.

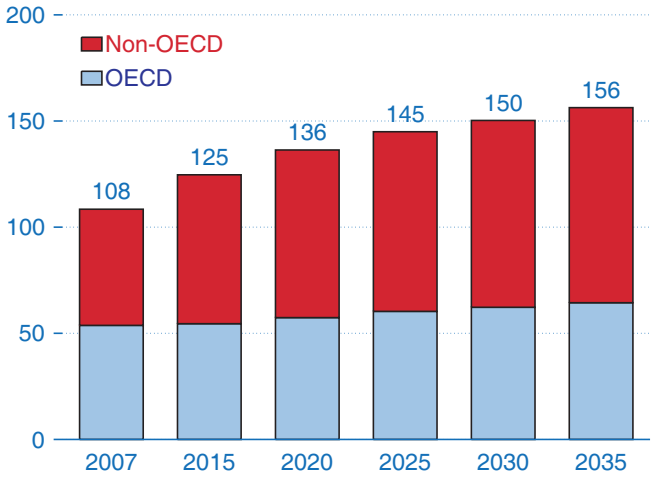
Overview

Total natural gas consumption worldwide increases 44 percent in the *IEO2010* Reference case, from 108 trillion cubic feet in 2007 to 156 trillion cubic feet in 2035 (Figure 36). Demand for natural gas slowed in 2008 as the global economic recession began to affect world energy markets, and in 2009 world consumption of natural gas contracted by an estimated 1.1 percent. The impact of the recession on natural gas use was especially evident in the industrial sector—the end-use sector with the highest level of natural gas consumption—where demand for natural gas declined by an estimated 6 percent from 2008 to 2009.

As world economies begin to recover from the economic downturn, global demand for natural gas rebounds. Nonetheless, natural gas supplies from a variety of sources help keep markets well supplied and prices relatively low. In the Reference case, natural gas consumption expands by an average of 1.8 percent per year from 2007 to 2020. From 2020 to 2035, the growth in consumption of natural gas slows to an average of 0.9 percent per year, as prices rise and increasingly expensive natural gas resources are brought to market.

Natural gas remains a key energy source for industrial uses and for electricity generation throughout the projection. The industrial sector accounted for approximately 40 percent of total world natural gas use in 2007, and it maintains that share through 2035. Because natural gas produces less carbon dioxide when it is burned than does either coal or petroleum, governments implementing national or regional policies to reduce greenhouse gas emissions may encourage its use to displace other fossil fuels. In the electric power sector, for example, natural gas is often an attractive choice for new generating plants because of its relative fuel efficiency, low emissions, quick construction timelines, and low capital costs. Electricity generation in the Reference case becomes an increasingly important part of the world's natural gas consumption, accounting for 36 percent of the world total in 2035, up from 33 percent in 2007.

Figure 36. World natural gas consumption, 2007-2035 (trillion cubic feet)



Natural gas consumption in non-OECD countries grows approximately three times as fast as consumption in OECD countries in the Reference case, with increases averaging 1.9 percent per year for non-OECD countries and 0.6 percent per year for OECD countries from 2007 to 2035. As a result, non-OECD countries account for 78 percent of the total world increment in natural gas consumption over the projection period, and the non-OECD share of total world natural gas consumption increases from 50 percent in 2007 to 59 percent in 2035.

The major projected increase in natural gas production is expected to occur in non-OECD regions, with the largest increments coming from the Middle East (an increase of 16 trillion cubic feet between 2007 and 2035), Africa (7 trillion cubic feet), and Russia and the other countries of non-OECD Europe and Eurasia (6 trillion cubic feet) (Figure 37). Over the projection period, Iran and Qatar alone increase their natural gas production by a combined 12 trillion cubic feet, nearly one-fourth of the total increment in world gas production. A significant share of the increase is expected to come from a single offshore field, which is called North Field on the Qatari side and South Pars on the Iranian side.

Although the extent of the world's tight gas, shale gas, and coalbed methane resource base has not yet been assessed fully, the *IEO2010* Reference case projects a substantial increase in those supplies—especially in the United States, but also in Canada and China. In the United States, one of the keys to increasing natural gas production has been advances in horizontal drilling and hydraulic fracturing technologies, which have made it possible to develop the country's vast shale gas

resources, and have helped to increase total U.S. natural gas resources by almost 50 percent over the past decade. Shale gas accounts for 26 percent of U.S. natural gas production in 2035. Tight gas, shale gas, and coalbed methane resources are even more important for the future of domestic natural gas supplies in Canada and China, where they account for 63 percent and 56 percent of total domestic production, respectively, in 2035 in the Reference case.

Liquefied natural gas (LNG) accounts for a growing share of world natural gas trade in the Reference case. World natural gas liquefaction capacity increases 2.4-fold, from about 8 trillion cubic feet in 2007 to 19 trillion cubic feet in 2035. Most of the increase in liquefaction capacity is in the Middle East and Australia, where a multitude of new liquefaction projects are expected to be developed, many of which will become operational within the next decade. Utilization of liquefaction capacity is expected to remain high during the entire projection period. Given the capital-intensive nature of liquefaction projects, long-term contracts requiring the purchase of high volumes (or high "takes") are often used to ensure high utilization rates and acceptable returns on investments.

Despite the growing importance of LNG, long-distance pipelines remain an important component of world gas trade. As indigenous natural gas production in OECD Europe declines, its import demand increases, driving much of the global growth in pipeline traded gas. The other major factor in the growth of piped gas is rising natural gas demand in Asia, particularly China.

World natural gas consumption

OECD natural gas consumption

Natural gas consumption in North America increases by 0.7 percent per year in the *IEO2010* Reference case, from 28.3 trillion cubic feet in 2007 to 34.6 trillion cubic feet in 2035, accounting for 59 percent of the total increase for OECD countries and 13 percent of the total increase for the world over the projection period. U.S. consumption increases by 0.3 percent per year on average (Figure 38), considerably less than the annual increases in Canada (1.4 percent) and Mexico (3.0 percent). Mexico accounts for almost 50 percent of the growth in North America's natural gas consumption, the United States about 30 percent, and Canada about 20 percent.

In the United States, natural gas use declines initially (from 2007 through 2015) as a result of slow growth in electricity demand, completion of coal-fired plants currently under construction, and additions of new renewable capacity. U.S. natural gas consumption falls to 21.7 trillion cubic feet in 2015 before the decline reverses, then returns to 2007 levels shortly before 2025. Most of the growth is provided by demand increases of 0.6 trillion cubic feet for electricity generation and 0.7 trillion cubic feet for use in commercial buildings.

In Mexico, the strong growth in natural gas consumption is concentrated almost exclusively in the electricity generation and industrial sectors, where consumption grows by 2.0 and 1.1 trillion cubic feet, respectively, from 2007 to 2035. In Canada, 59 percent of the growth in natural gas demand is for industrial uses (including significant amounts of natural gas used for the mining of Canada's vast oil sands deposits) and 24 percent is for electricity generation.

Natural gas consumption in OECD Europe grows by 0.5 percent per year on average, from 19.2 trillion cubic feet in 2007 to 21.9 trillion cubic feet in 2035 (Figure 39), primarily as a result of increasing demand in the electric power sector. Natural gas accounts for about one-fourth of the region's total energy consumption over the projection period, with the coal and liquids shares declining

Figure 37. Change in world natural gas production by region, 2007-2035 (trillion cubic feet)

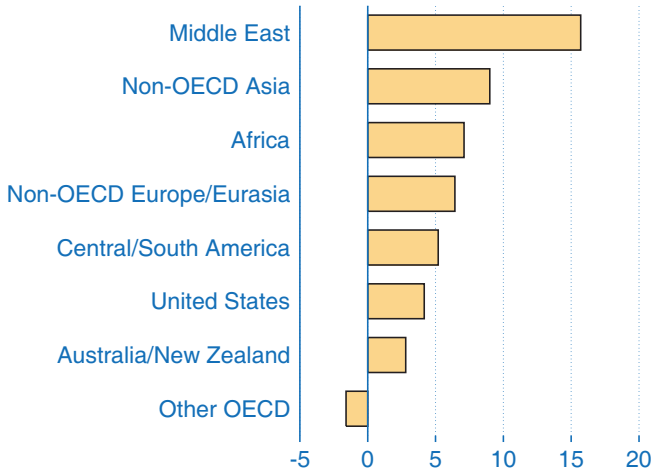
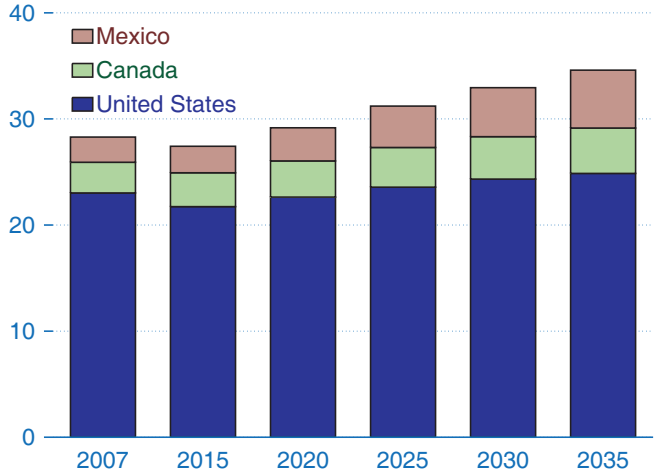


Figure 38. Natural gas consumption in North America by country, 2007-2035 (trillion cubic feet)



from their earlier levels. Many governments in OECD Europe have made commitments to reduce greenhouse gas emissions and promote development of "clean energy." Because natural gas is less carbon-intensive than either coal or petroleum, it is a more environmentally attractive option and thus is likely to remain an important fuel for Europe's electric power sector development in the long term.

Natural gas consumption in OECD Asia grows on average by 0.8 percent per year from 2007 to 2035, with Japan, South Korea, and Australia/New Zealand each adding less than 1 trillion cubic feet of natural gas consumption over the period (Figure 40). Total natural gas consumption for the region as a whole increases from 6.3 trillion cubic feet in 2007 to 8.0 trillion cubic feet in 2035.

Japan's natural gas consumption grows modestly, by an average of 0.2 percent per year, from 3.7 trillion cubic feet in 2007 to 4.0 trillion cubic feet by 2035. A declining population and aging labor force limit the country's natural gas demand in the long term. Moreover, new nuclear generation capacity projected for Japan limits the need for additional natural-gas-fired generation after 2015.

South Korea's demand for natural gas grows by 1.4 percent per year from 2007 to 2035, led by strong growth in the electric power sector. The share of the country's natural gas consumption used for electricity generation increases from 39 percent in 2007 to 48 percent in 2035. As deregulation in the electric power sector moves forward, South Korea's electricity producers will be able to contract directly with global LNG suppliers, stimulating further growth in natural gas demand for the electric power sector. In the buildings sector, where natural gas consumption has grown robustly over the past two decades with the development of South Korea's national natural gas transmission grid, consumption growth slows somewhat. Still, natural gas use in the buildings sector increases by approximately 126 billion cubic feet from 2007 to 2035, making up about one-fifth of the country's total increase in natural gas use of 596 billion cubic feet in the *IEO2010* Reference case.

In Australia/New Zealand, the industrial sector is the predominant consumer of natural gas, accounting for about 60 percent of the region's total natural gas consumption in 2007. This remains the case throughout the projection. Natural gas use in the electric power sector grows modestly, from 0.3 trillion cubic feet in 2007 to 0.6 trillion cubic feet in 2035, as Australia—in its efforts to reduce carbon dioxide emissions—gradually increases the share of natural gas in its power generation mix to diversify away from its more carbon-intensive coal-fired generation.

Non-OECD natural gas consumption

The countries of non-OECD Europe and Eurasia rely on natural gas for more than 50 percent of their primary energy needs—a larger share than for any other country grouping in the *IEO2010* Reference case. Russia is the world's second-largest consumer of natural gas after the United States, with demand totaling 16.7 trillion cubic feet in 2007 and representing 55 percent of Russia's total energy consumption. In the Reference case, Russia's natural gas consumption grow at a modest average rate of 0.2 percent per year from 2007 to 2035. As the country makes progress in liberalizing domestic natural gas prices to approach parity with international market values, increasing fuel costs for natural-gas-fired plants are likely to make them less competitive with other baseload generation. Furthermore, expected efficiency improvements and other demand-side management measures

Figure 39. Natural gas consumption in OECD Europe by end-use sector, 2007-2035 (trillion cubic feet)

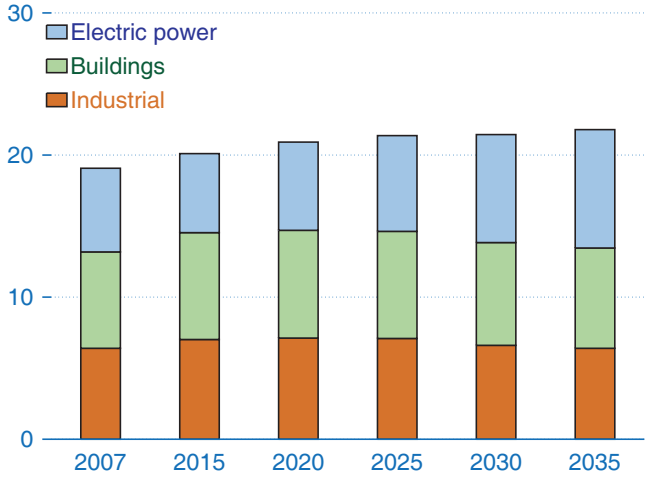
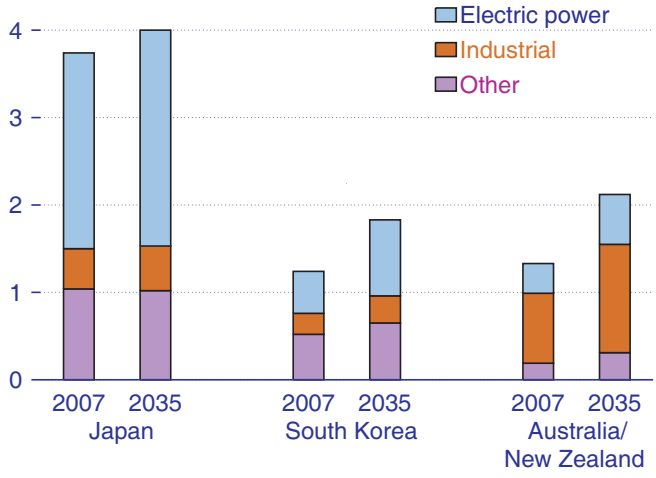


Figure 40. Natural gas consumption in OECD Asia by country and end-use sector, 2007 and 2035 (trillion cubic feet)



will limit growth in natural gas demand over the long term.

In the countries of non-OECD Europe and Eurasia other than Russia, natural gas consumption grows by 0.6 percent annually over the projection period, from 9.1 trillion cubic feet in 2007 to 10.9 trillion cubic feet in 2035 (Figure 41). Natural gas is the largest component of the countries' primary energy consumption, representing more than 45 percent of the total throughout the projection period. The industrial sector remains the region's largest consumer of natural gas, with a share of approximately 40 percent of total gas consumption throughout the projection period. In the long term, rising prices for both domestically produced and imported natural gas are likely to moderate the region's growth in natural gas demand.

Among all regions of the world, the fastest growth in natural gas consumption is projected for non-OECD Asia, which accounts for 35 percent of the total increment in natural gas use in the Reference case and nearly doubles its share of total world natural gas consumption from about 10 percent in 2007 to 18 percent in 2035. Natural gas use in non-OECD Asia increases by an average of 3.5 percent annually over the projection period, from 10.5 trillion cubic feet in 2007 to 27.5 trillion cubic feet in 2035 (Figure 42).

India and China lead the growth in natural gas demand in non-OECD Asia. In both India and China, natural gas currently is a minor part of the overall energy mix, accounting for only 7 percent and 3 percent, respectively, of total energy consumption in 2007. Those shares nearly double in the projection, however, to 12 percent in India and 6 percent in China, adding a combined 10.2 trillion cubic feet of natural gas consumption between 2007 and 2035. In the rest of the countries of non-OECD Asia, natural gas consumption increases by a total of 6.7 trillion cubic feet from 2007 to 2035.

China's central government is promoting natural gas as a preferred energy source. It has set an ambitious target of increasing the share of natural gas in its overall energy mix to 10 percent by 2020 [***1***]. In the *IEO2010* Reference case, China's natural gas consumption grows at an average rate of 5.0 percent annually over the forecast period—the highest growth rate worldwide—to a total of 9.7 trillion cubic feet in 2035. Nevertheless, China does not achieve its targeted natural gas share, as coal continues to fulfill the country's largest share of energy demand. Natural gas provides 5 percent of China's energy supply in 2020 in the Reference case.

In the other countries of non-OECD Asia, natural gas already is a large component of the energy mix, representing 23 percent of their combined total energy consumption in 2007. In the Reference case, their natural gas consumption doubles from 6.6 trillion cubic feet in 2007 to 13.3 trillion cubic feet in 2035. Several countries in the region are building LNG receiving terminals and will join the league of LNG importers in the next few years. Indonesia, in response to strong growth in domestic demand, has established policies to prioritize domestic consumption of natural gas over exports [***2***].

In the Middle East and Africa, natural gas consumption has grown substantially in recent years, stimulated by increased economic activity, large investments in new infrastructure, and domestic price subsidies. Despite significant growth in natural gas production over the past decade, several countries in the Middle East have experienced domestic supply shortfalls resulting from rapidly growing demand in the electric power and industrial sectors. As a result, some of those countries have established policies assigning priority to domestic natural gas use over exportation. Also in development are various approaches to phasing out price subsidies in order to align domestic natural gas prices with export prices.

Figure 41. Natural gas consumption in Non-OECD Europe and Eurasia, 2007-2035 (trillion cubic feet)

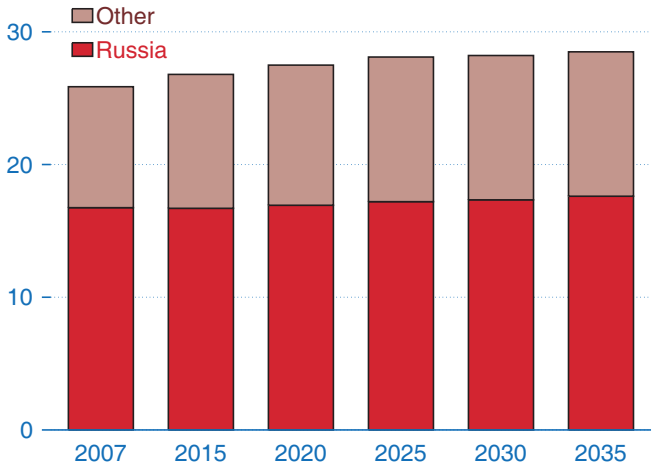
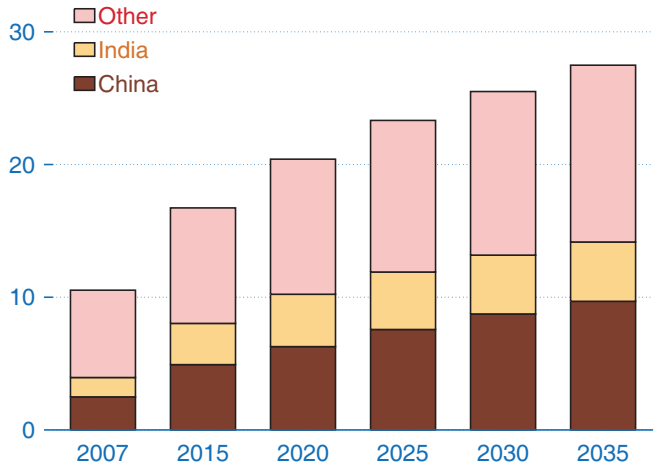


Figure 42. Natural gas consumption in Non-OECD Asia by country, 2007-2035 (trillion cubic feet)



In the Middle East, natural gas consumption nearly doubles between 2007 and 2035, growing at an average annual rate of 2.4 percent over the forecast period. The region's industrial and electric power sectors remain the most important natural gas consumers, with shares of approximately 50 percent and 40 percent of total use, respectively, in 2035. Growth in industrial consumption is driven by the petrochemical industry, primarily in Saudi Arabia, Iran, Qatar, and UAE. Natural gas use in the region's electric power sector nearly doubles from 2007 to 2035 with an overall increase of 3.9 trillion cubic feet. Several countries in the region have opted to import natural gas in the form of LNG. Kuwait started importing LNG in 2009, and Dubai plans to begin in 2010.

In Africa, the electric power sector drives the increase in natural gas demand over the projection period, as Africa's total natural gas consumption increases from 3.1 trillion cubic feet in 2007 to 6.8 trillion cubic feet in 2035. In West Africa, Nigeria is taking measures to end natural gas flaring and to prioritize domestic natural gas use over exportation in order to support growing consumption in the electric power sector. Similarly, in Egypt, the government announced a moratorium on new export contracts until 2010. In order to continue development of its natural gas reserves, however, Egypt will need to maintain investment from international oil and gas companies developing those reserves. Toward that end, domestic natural gas prices will have to be competitive with international prices.

In Central and South America, natural gas use increases at a rate that is second only to the rate of increase in nuclear energy use. However, nuclear electricity generation is growing from a very small base and remains a minor part of the region's total energy consumption. Natural gas demand increases on average by 2.3 percent per year, from 4.6 trillion cubic feet in 2007 to 8.6 trillion cubic feet in 2035.

Although parts of Central and South America have well-developed natural gas pipeline infrastructure, supply disruptions and political disagreements in recent years have raised concerns about security of supply and have prompted several countries to look to imported LNG as a long-term supply solution. Brazil is developing its own domestic resources and also imports large quantities of natural gas from Bolivia via pipeline. It has not been able to meet its burgeoning demand, however, and in 2008 it inaugurated an LNG import terminal [*3*]. Argentina also commenced LNG imports in 2008 [*4*]. Chile, faced with disruptions of natural gas supply from Argentina as a result of Argentina's own natural gas supply shortages, commissioned its first LNG receiving terminal in July 2009 and has another terminal under construction [*5*]. Also, a proposed new regasification terminal in Uruguay could be operational as early as 2012 [*6*].

World natural gas production

In order to meet the demand growth projected in the *IEO2010* Reference case, the world's natural gas producers will need to increase supplies by almost 50 trillion cubic feet between 2007 and 2035. Much of the increase in supply is expected to come from non-OECD countries, which in the Reference case account for 89 percent of the total increase in world natural gas production from 2007 to 2035. Non-OECD natural gas production grows by an average of 1.8 percent per year in the Reference case, from 67 trillion cubic feet in 2007 to 111 trillion cubic feet in 2035 (Table 6), while OECD production grows by only 0.4 percent per year, from 40 trillion cubic feet to 45 trillion cubic feet.

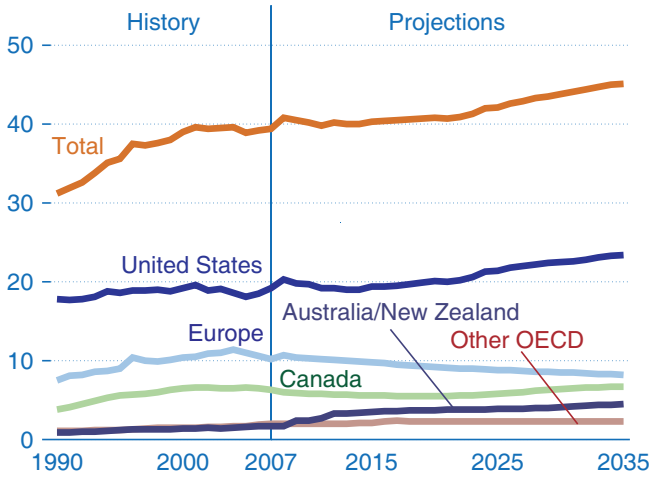
OECD natural gas production

Natural gas production in OECD nations increases by 5.3 trillion cubic feet from 2007 to 2035 in the Reference case (Figure 43). The largest increases are in the United States (4.2 trillion cubic feet) and Australia/ New Zealand (2.8 trillion cubic feet). The production increases projected for the two regions are offset in part by production declines in OECD Europe, where smaller increases in tight gas, shale gas, and coalbed methane production are insufficient to offset declines in conventional natural gas production.

North America's natural gas production grows by 18 percent over the projection period. The United States, which is by far the largest producer in North America, accounts for more than 85 percent of the total production growth, with an increase from 19.2 trillion cubic feet in 2007 to 23.4 trillion cubic feet in 2035.

One of the keys to U.S. production growth is advancement in production technologies, such as horizontal drilling and hydraulic fracturing. Advances made to date have allowed for the exploitation of vast shale gas

Figure 43. OECD natural gas production by country, 1990-2035 (trillion cubic feet)



resources, which are found in most U.S. production regions but concentrated mainly in the eastern and Gulf Coast States. Rising estimates of shale gas resources have been the primary factor in increasing U.S. technically recoverable natural gas resources by almost 50 percent over the past decade.

U.S. production from shale gas formations is expected to increase more than fivefold between 2007 and 2035, more than offsetting a decline in conventional natural gas production. Increases in Alaskan production and offshore production in the lower 48 States also contribute to the growth. Favorable economic conditions are expected to support the completion of an Alaska pipeline, which in the Reference case begins transporting natural gas to the lower 48 States in 2023. In 2035, shale gas accounts for 26 percent of total U.S. natural gas production, lower 48 offshore production accounts for 19 percent, and Alaska and coalbed methane resources account for 8 percent each. The remaining 39 percent comes from other associated and nonassociated lower 48 onshore resources.

Canada's natural gas production declines from 6.3 trillion cubic feet in 2007 to 5.5 trillion cubic feet in 2020 in the Reference case, followed by production increases as the exploitation of shale gas, tight gas, and coalbed methane resources reverses the decline in overall production. Canada's natural gas production totals 6.7 trillion cubic feet in 2035. Mexico's natural gas production remains fairly flat, growing only from 1.8 trillion cubic feet in 2007 to 2.1 trillion cubic feet in 2035. The country faces substantial difficulties in attracting the investment and technology improvements needed to increase production.

In OECD Europe, production from tight gas, shale gas, and coalbed methane resources is not expected to arrest the ongoing decline in total production as it has in the United States in recent years (Figure 44). Those resources are estimated to be smaller in Europe than in North America, and their development faces substantial hurdles in terms of cost, infrastructure, regulation, and public acceptance. In the Reference case, natural gas production in OECD Europe declines at an average annual rate of 0.9 percent over the projection period, from 10.2 trillion cubic feet in 2007 to 8.0 trillion cubic feet in 2035.

Both Japan and South Korea have limited natural gas resources and, consequently, very limited current and

Table 6. World natural gas production by region and country in the Reference case, 2007-2035 (trillion cubic feet)

	History		Projections					Average annual percent change, 2007-2035
Region/country	2007	2008	2015	2020	2025	2030	2035	
OECD North America								
United States[a]	19.2	20.3	19.4	20.1	21.4	22.5	23.4	0.7
Canada	6.3	6.0	5.6	5.5	5.8	6.4	6.7	0.2
Europe	10.2	10.7	9.6	9.0	8.6	8.3	8.0	-0.9
Australia/New Zealand	1.7	1.7	3.5	3.7	3.9	4.1	4.5	3.5
Other OECD	2.0	2.0	2.1	2.3	2.2	2.2	2.2	0.3
Total OECD	**39.5**	**40.8**	**40.2**	**40.5**	**41.9**	**43.5**	**44.8**	**0.4**
Non-OECD								
Russia	23.1	23.4	23.0	24.3	25.3	26.5	27.3	0.6
Europe and Central Asia	7.3	7.8	9.2	9.5	9.6	9.5	9.5	0.9
Iran	4.0	4.1	6.4	8.0	8.7	9.0	8.7	2.9
Qatar	2.2	2.7	6.4	7.4	8.2	9.2	9.5	5.3
Other Middle East	6.4	6.7	8.1	9.2	9.7	9.6	10.2	1.7
North Africa	5.3	5.4	8.2	9.0	9.7	9.9	9.8	2.2
Other Africa	1.6	1.7	3.1	3.7	4.0	4.2	4.2	3.6
China	2.4	2.7	2.9	3.0	3.4	4.5	5.6	3.0
Other Asia	9.6	9.9	12.9	14.2	14.9	15.3	15.4	1.7
Central and South America	5.2	5.3	6.6	8.7	9.4	10.0	10.5	2.5
Total Non-OECD	**67.0**	**69.7**	**86.8**	**97.0**	**103.0**	**107.7**	**110.6**	**1.8**
Total World	**106.6**	**110.5**	**126.9**	**137.5**	**144.8**	**151.1**	**155.4**	**1.4**
Discrepancy[b]	1.9	0.7	-2.3	-1.1	0.1	-0.9	0.9	

[a]Includes supplemental production, less any forecast discrepancy.
[b]Balancing item. Differences between global production and consumption totals result from independent rounding and differences in conversion factors derived from heat contents of natural gas that is produced and consumed regionally.

future production. Both countries receive the vast majority of their natural gas supplies in the form of imported LNG. In 2007, natural gas production in Japan and South Korea accounted for only 5 percent and 1 percent of their natural gas consumption, respectively. Although the presence of substantial deposits of methane hydrates in both Japan and South Korea has been confirmed, and both countries are investigating how those resources could be safely and economically developed, the *IEO2010* Reference case does not include methane hydrate resources in its estimates of natural gas resources, and the development of hydrates on a commercial scale is not anticipated during the projection period.

Natural gas production in the Australia/New Zealand region grows from 1.7 trillion cubic feet in 2007 to 4.5 trillion cubic feet in 2035 in the Reference case, at an average rate of 3.5 percent per year—the strongest growth in natural gas production among OECD regions. In 2007, the Northwest Shelf area of Australia's Carnarvon Basin accounted for around 56 percent of total production in the Australia/New Zealand region [*7*], with much of the production used as feedstock at the Northwest Shelf LNG liquefaction facility. Other areas and basins in Australia provided another 35 percent of the region's total production in 2007. New Zealand's natural gas production accounted for around 9 percent of the 2007 regional total.

Coalbed methane, from the Bowen-Surat Basin in eastern Australia, accounted for between 5 percent and 7 percent of total production in Australia in 2007 [*8*], and its share is certain to grow in the future. The Cooper Basin has also been a source of natural gas supply since 1969, but its production is in decline. Coalbed methane production from the Bowen-Surat Basin is expected to offset declines from the Cooper Basin in the future, providing natural gas supplies to satisfy the area's demand growth and to feed proposed LNG export projects.

Non-OECD natural gas production

Middle East production

Four major natural gas producers in the Middle East—Qatar, Iran, Saudi Arabia, and the United Arab Emirates—together accounted for 84 percent of the natural gas produced in the Middle East in 2007. With more than 40 percent of the world's proved natural gas reserves, the Middle East accounts for the largest increase in regional natural gas production from 2007 to 2035 (Figure 45) and for nearly one-third of the total increment in world natural gas production in the Reference case.

In the *IEO2010* Reference case, the strongest growth among Middle East producers from 2007 to 2035 comes from Qatar, where natural gas production increases by 7.2 trillion cubic feet, followed by Iran (4.8 trillion cubic feet of new production) and Saudi Arabia (2.2 trillion cubic feet). Although Iraq is the region's fastest-growing supplier of natural gas, at 11.6 percent per year over the projection, it is a relatively minor contributor to regional gas supplies. In 2035, Iraq's natural gas production totals only 1.1 trillion cubic feet, or about 4 percent of the Middle East total.

Iran has the world's second-largest reserves of natural gas, after Russia, and currently is the Middle East's largest natural gas producer. Iran is also the Middle East's largest user of reinjected natural gas for enhanced oil recovery operations. In 2007, Iran reinjected more than 1 trillion cubic feet of natural gas, or 16 percent of its gross production. In 2009, Iran began enhanced oil recovery operations at the Agha-Jari oil field, where it plans to raise oil production by 60,000 barrels per day by injecting 1.3 trillion cubic feet of natural gas annually, more than doubling the 2007 reinjected volumes [*9*]. In 2020, Iran is estimated to need between 3.7 trillion and 7.3 trillion cubic feet of natural gas per year for

Figure 44. OECD Europe natural gas production, 1990-2035 (trillion cubic feet)

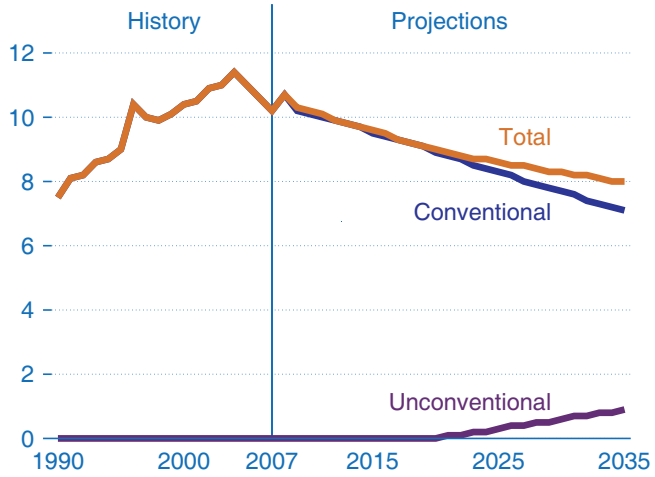
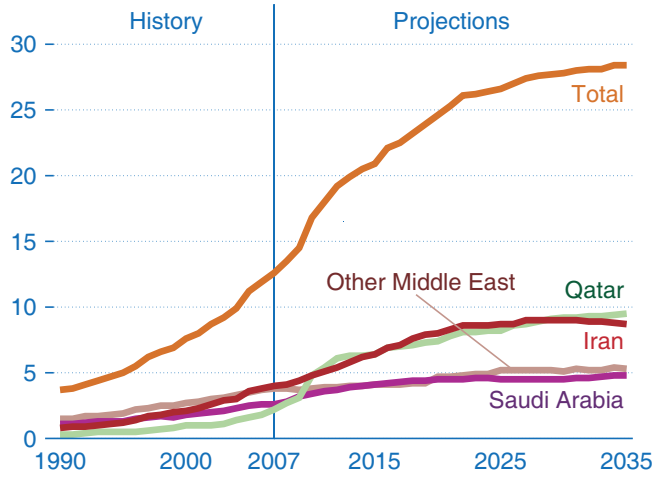


Figure 45. Middle East natural gas production, 1990-2035 (trillion cubic feet)



reinjection [***10***]. The higher estimate is close to the projected total for Iran's marketed natural gas production in 2020. The actual figure for reinjection use, whatever it turns out to be, will have a significant impact on Iran's future marketed natural gas production.

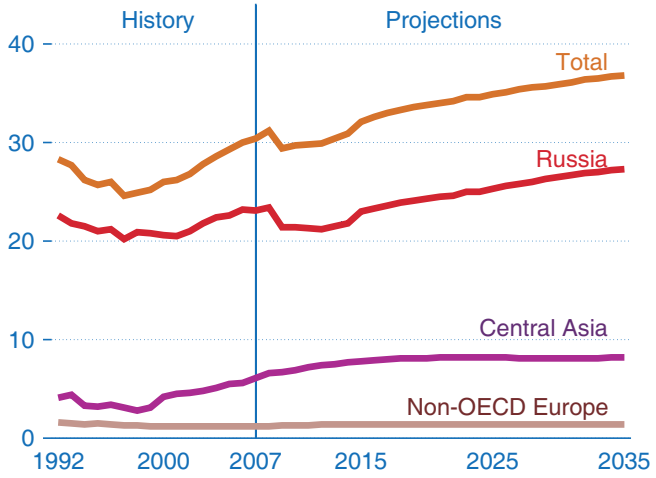
Natural gas production in Saudi Arabia grows at an average annual rate of 2.2 percent, from 2.6 trillion cubic feet in 2007 to 4.8 trillion cubic feet in 2035. The Saudi national oil company, Saudi Aramco, has made several natural gas finds in the Persian Gulf that are not associated with oil fields. Three fields, the Karan, Arabiyah and Hasbah, are expected to begin producing in the next 5 years, adding at least 1.3 trillion cubic feet of production when fully operational. Both Arabiyah and Hasbah are offshore, and both are also sour natural gas fields, making them relatively expensive to produce, with an estimated cost of $3.50 to $5.50 per million Btu [***11***]. The *IEO2010* Reference case assumes that Saudi Arabia's policy of reserving natural gas production for domestic use persists throughout the projection period, and that no natural gas is exported. Thus, in the long term, production is more dependent on domestic demand growth and domestic prices than on resource availability.

Non-OECD Europe and Eurasia production

After the Middle East, the world's second-largest regional increase in natural gas production is expected in non-OECD Europe and Eurasia, which includes Russia, Central Asia, and non-OECD Europe. In the Reference case, natural gas production in the region as a whole increases from 30.4 trillion cubic feet in 2007 to 36.8 trillion cubic feet in 2035 (Figure 46). Russia remains the dominant natural gas producer, accounting for more than 70 percent of the region's production throughout the projection.

In 2007, Russia produced 23.1 trillion cubic feet of natural gas. Preliminary EIA data for 2008 show a 1.4-percent increase in natural gas production over 2007, to 23.4 trillion cubic feet. Early estimates for 2009, however, indicate a decline of 12.4 percent (2 to 3 trillion cubic feet) in Russia's natural gas production from the 2008 total [***12***]. The production decline was due not to a lack of resources or production capacity, but rather to the global economic downturn and the resultant decline in natural gas demand in Russia and in its gas export markets, especially those in Europe. Russia's exports to Europe were down by 24.5 percent in 2009, and its total natural gas exports were down by almost 9 percent, offset in part by new LNG exports from Sakhalin II to Asian markets [***13***]. In the *IEO2010* Reference case, Russia's natural gas production largely recovers by 2015. Nevertheless, the long-term outlook remains less optimistic than it was in *IEO2009*, mainly as a result of lower projections for natural gas demand in Russia and Europe in *IEO2010*.

Figure 46. Non-OECD Europe and Eurasia natural gas production, 1992-2035 (trillion cubic feet)



The recent natural gas supply-demand balances in Europe and North America, and their implications for the future, are affecting investment and future production plans in Russia. Official development plans for the giant Shtokman field in Russia's Arctic offshore had called for first pipeline natural gas and LNG to begin to flow in 2014. In early 2010, however, those plans were revised, pushing the official target date for first pipeline flows back to 2016 and for first LNG flows back to 2017 [***14***]. It had been widely believed that the pipeline flows from the Shtokman field would be used to fill the second pipe of the Nord Stream export pipeline to Germany and beyond. With Russian pipeline exports to Europe down so severely in 2009, however, many doubt the need for the additional export capacity that the second pipeline would provide. Furthermore, North America had been the intended market for LNG exports from the Shtokman field, but recent declines in expectations of future U.S. demand for natural gas imports have led many to conclude that North America will be relatively self-sufficient in natural gas production for some time to come and will not need large volumes of imported LNG.

Despite the uncertain future of natural gas import demand in Europe and North America, Russia must still invest in new fields if it is to realize its goal of increasing exports to Asia. Moreover, it will require such investments simply to maintain total natural gas production levels, because production at its three largest fields (Yamburg, Urengoy, and Medvezh'ye) is in decline [***15***]. Accordingly, investment is proceeding at the Bovanenkovo field on Russia's northern Yamal Peninsula and at the Chayandinskoye field in eastern Siberia, among other projects. The Bovanenkovo field is currently scheduled to start production in the third quarter of 2012, ramping up production from an initial 0.3 trillion cubic feet per year to an eventual level of almost 5 trillion cubic feet per year [***16***]. Output from the Bovanenkovo field is aimed mainly at Western markets, while production from the smaller and more easterly

Chayandinskoye field is aimed at Asian markets. Production from Chayandinskoye could eventually reach a peak of slightly more than 1 trillion cubic feet per year. Initial production is currently planned for 2016, but the actual start date is dependent on the agreements and infrastructure that must be in place before the natural gas can be exported to Asia [*17*].

Natural gas production in Central Asia (which includes the former Soviet Republics) grows by 1.0 percent per year on average, from 6.1 trillion cubic feet in 2007 to 8.2 trillion cubic feet in 2035. Much of the growth is expected to come from Turkmenistan, which already is a major producer accounting for 40 percent of the region's total production in 2007. Turkmenistan is just beginning to develop its recently assessed giant Yolotan field. It will be developed in several phases, with each of the initial four phases adding around 0.4 trillion cubic feet of annual natural gas production and the first production expected in 2010 or 2011 [*18*]. Initial natural gas production from the Yolotan field will probably be exported by pipeline to China, with further expansion of Turkmen and Central Asian production dependent on securing markets and transit routes to reach those markets. Also contributing to Central Asia's projected production growth is Azerbaijan, which has been planning to bring on line the second phase of natural gas production at its Shah Deniz field. Upon reaching peak production, Shah Deniz will add around 0.7 trillion cubic feet to the country's annual production.

Africa production

Substantial growth in natural gas production is also projected for Africa, where production increases from 6.8 trillion cubic feet in 2007 to 12.7 trillion cubic feet in 2020 and 14.0 trillion cubic feet in 2035 (Figure 47). In 2007, 77 percent of Africa's natural gas was produced in North Africa, mainly in Algeria, Egypt, and Libya. West Africa accounted for another 20 percent of the 2007 total, and the rest of Africa accounted for 3 percent. Remaining resources are more promising in West Africa than in North Africa, which has been producing large volumes of natural gas over a much longer period. Indeed, faster production growth is projected for West Africa, with an average annual rate of 4.0 percent, versus 2.2 percent for North Africa.

Nigeria is the predominant natural gas producer in West Africa, although recent production increases in the region have also come from Equatorial Guinea, which brought an LNG liquefaction facility on line in 2007. Angola also is expected to add to West Africa's production in the near term, with its first LNG liquefaction facility, currently under construction, expected to come on line in 2012 [*19*]. Still, because security concerns and uncertainty over terms of access in Nigeria limit production growth in West Africa, North Africa remains the continent's leading region for natural gas production over the course of the projection.

Non-OECD Asia production

Non-OECD Asia's natural gas production increases by 8.9 trillion cubic feet from 2007 to 2035 in the Reference case, with China accounting for 35 percent of the growth and India 24 percent (Figure 48). Another 30 percent of the growth is attributed to the Asian LNG-exporting countries, including traditional exporters Indonesia, Malaysia, and Brunei, as well as Papua New Guinea, which appears poised to become a significant LNG exporter within the next 5 to 10 years.

From 2007 to 2035, China has the largest projected increase in natural gas production in non-OECD Asia, from 2.4 trillion cubic feet in 2007 to 5.6 trillion cubic feet in 2035, for an average annual increase of 3.0 percent (Figure 49). Increases in natural gas supplies that are easily accessible account for most of the total production growth between 2007 and 2020. After 2020, continued

Figure 47. Africa natural gas production, 1990-2035 (trillion cubic feet)

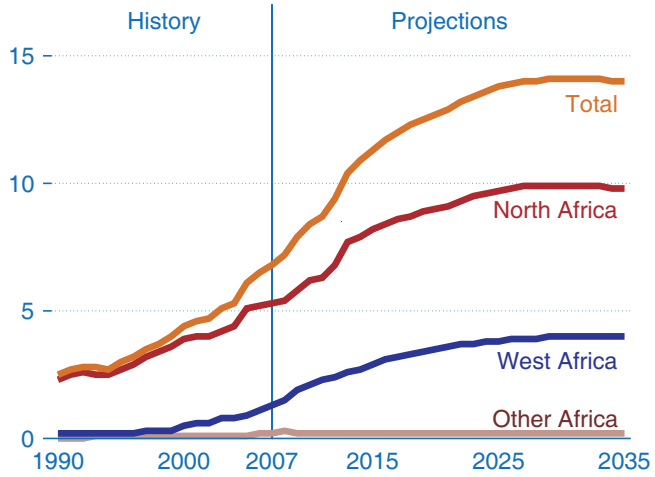
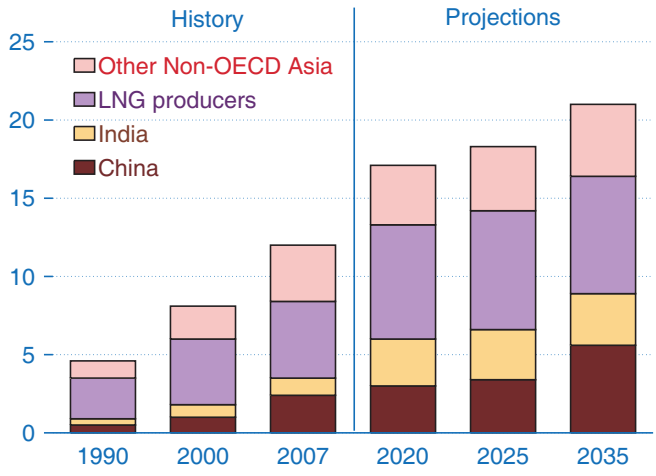


Figure 48. Non-OECD Asia natural gas production, 1990-2035 (trillion cubic feet)



growth in natural gas production in China comes from more expensive tight gas, shale gas, and coalbed methane resources, which in 2035 provide more than three times as much production as the same three resource types in OECD Europe.

The outlook for unconventional natural gas production is more positive in China than in OECD Europe first and foremost because China's geology suggests a greater unconventional resource potential than in Europe. Further, although natural gas production from conventional resources in China, as in Europe, cannot keep up with domestic demand, China's government strongly supports unconventional gas development, and public resistance is likely to be less of an impediment in China than in OECD Europe. The outlook for unconventional natural gas production is also more positive in China than in the rest of the non-OECD countries, because China is unique among non-OECD nations in having both significant unconventional gas potential and insufficient conventional natural gas resources to satisfy growing demand through 2035.

Natural gas production in India grows at an average annual rate of 4.0 percent over the projection period, the fastest growth in non-OECD Asia. Most of the growth in India's natural gas production is expected in the near term, averaging 11.7 percent per year as total production grows from 1.1 trillion cubic feet in 2007 to 2.7 trillion cubic feet in 2015. The increase is due mainly to a single development. Production from the Dhirubhai-6 block in the Krishna Godavari Basin (KG-D6 block) began in April 2009 and reached an annual production rate of around 0.8 trillion cubic feet by mid-January 2010 [***20***]. Natural gas production from the KG-D6 block is ready to flow at its plateau rate of just over 1 trillion cubic feet per year as soon as the government-designated customers are ready to receive it. From 2015 to 2035, India's natural gas production grows much more slowly, by an average of 1.0 percent per year, as production from older fields declines.

Natural gas production in the LNG-exporting countries of non-OECD Asia grows at an average annual rate of only 1.6 percent. Indonesia, Malaysia, and Brunei currently export LNG, and Papua New Guinea is on the verge of becoming another regional LNG exporter in the near term. In 2007, Malaysia and Indonesia together accounted for more than 90 percent of total production from the four countries. In the future, however, significant production growth is expected for Papua New Guinea, where several proposed LNG export projects, if built according to plan, will require more than 0.7 trillion cubic feet per year of new natural gas production [***21***]. Both Malaysia and Indonesia, on the other hand, face declining production from many older fields and must make substantial investments to maintain current production levels. In the short term, Indonesia's natural gas production rises somewhat as the new Tangguh LNG export project, which came on line in the second half of 2009, ramps up to full production in 2010 [***22***].

Central and South America production

Natural gas production in Central and South America doubles between 2007 and 2035 (Figure 50). The fastest growth is projected for Brazil, averaging 7.4 percent per year. The majority of Brazil's current natural gas production comes from fields located offshore of the Rio de Janeiro and Espírito Santo states in the Campos and Espírito Santo basins, respectively. In addition, numerous recent discoveries of oil and natural gas in the subsalt Santos basin to the southwest of the Campos basin are expected to increase the country's natural gas production potential. The Merluza and Lagosta fields, a pair of smaller natural gas and condensate fields in the Santos basin, currently are producing and sending natural gas and liquids to shore via a pipeline that is more than 100 miles long [***23***]. By 2015, another pipeline,

Figure 49. China natural gas production, 1990-2035 (trillion cubic feet)

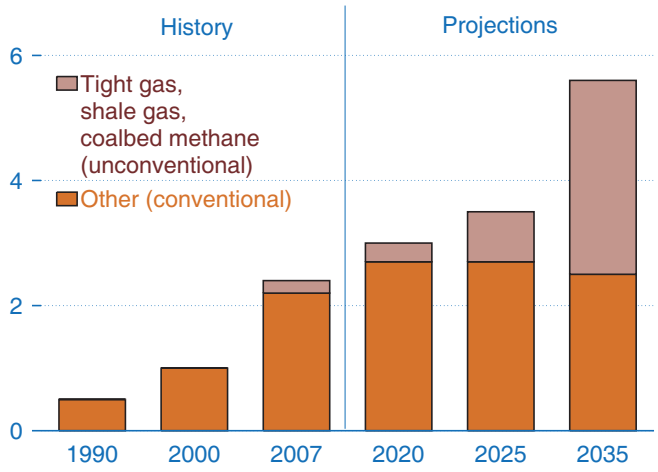
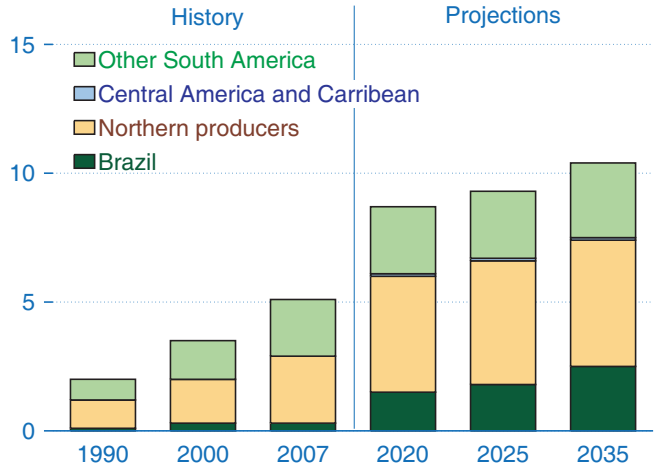


Figure 50. Central and South America natural gas production, 1990-2035 (trillion cubic feet)



stretching almost 100 miles, is planned to connect the Mexilhão field, a large non-associated natural gas field, to shore.

Other large Brazilian fields in the Santos Basin lie even farther from shore, and because of a lack of current infrastructure to bridge the distances, much of the initial natural gas production associated with oil extraction at the fields is likely to be reinjected. The Tambaú gas field and the Uruguá and Tupi oil fields have significant natural gas resources, and in the longer term there are plans to connect the three fields to shore with two separate pipelines, each stretching more than 100 miles and connecting to shore via the Mexilhão pipeline [***24***].

Another proposed option is to produce and liquefy Brazil's natural gas at sea, on floating platforms, from which the LNG could then be loaded onto ships for transport to existing LNG regasification terminals on the country's coast. Although several international oil companies currently are pursuing floating LNG liquefaction facilities, no such facilities have yet been developed or deployed. Petrobras, the owner and operator of most of Brazil's fields, has experience in the operation of floating production, storage, and offloading facilities for oil, which could help it in deploying a floating LNG plant. However, Petrobras does not possess LNG liquefaction technology of its own and would have to partner with another company for the project.

World natural gas trade

World natural gas trade grows in the *IEO2010* Reference case as OECD demand for non-OECD supplies continues to increase. Net natural gas imports by OECD countries increase at an average annual rate of 1.2 percent from 2007 to 2035. Most of the growth in OECD imports occurs in Europe, where net import demand increases from 9.0 trillion cubic feet in 2007 to 14.1 trillion cubic feet in 2035, to make up for falling domestic production. In North America, net import demand increases from 0.9 trillion cubic feet in 2007 to 2.6 trillion cubic feet in 2035, mostly because of Mexico's increasing need for imports to meet growing domestic demand.

Demand and import growth in Japan and South Korea, on the other hand, is relatively flat. Paired with strong growth in natural gas exports from Australia, this implies that as a region, OECD Asia's net demand for imports declines over the projection period, from 4.4 trillion cubic feet in 2007 to 3.4 trillion cubic feet in 2035. The declines in net import demand in OECD Asia, however, are overshadowed by increases in demand in the other OECD regions.

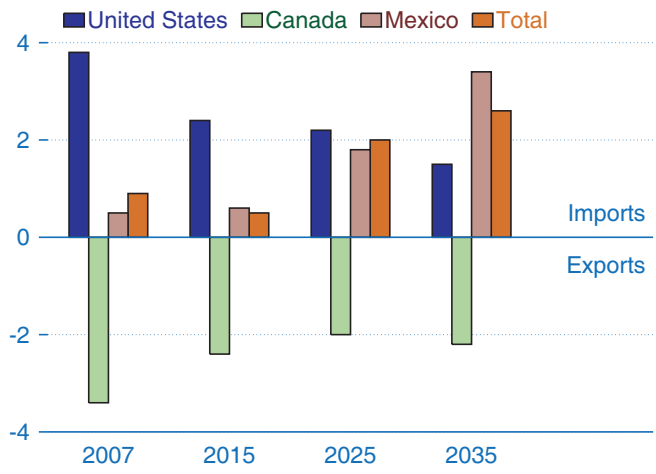
Net exports of natural gas from non-OECD countries grow from 12.3 trillion cubic feet in 2007 to 18.9 trillion cubic feet in 2035. Most of the growth occurs in the near term, as new LNG export projects in the Middle East and Africa and new natural gas pipelines from Africa to Europe come on line. Non-OECD Asia, with regional net exports of 1.5 trillion cubic feet of natural gas in 2007, becomes a net importer of natural gas by 2015, as China's imports grow rapidly with the completion of multiple LNG and pipeline import facilities.

OECD natural gas trade

North America's net imports of natural gas increase significantly in the Reference case, growing at an average annual rate of 3.9 percent from 2007 to 2035. The growth is attributable primarily to Mexico's growing dependence on imports, as its domestic production fails to keep pace with consumption growth. With Mexico's net imports growing from 0.5 trillion cubic feet in 2007 to 3.4 trillion cubic feet in 2035 (Figure 51), more than two-thirds of the increase is met by LNG, and the remainder is met by pipeline imports from the United States. There are two LNG facilities currently operational in Mexico, at Altamira on the east coast and in Baja California on the west coast. Another west coast terminal is under construction at Manzanillo, and several additional terminals are at various stages of the planning process and are expected to come on line by the end of the decade.

The rapid growth of shale gas production expected in the United States lessens the need for U.S. imports, and the *IEO2010* Reference case projects that net natural gas imports will decrease from 16 percent of total supply in 2007 to 6 percent in 2035. Several new LNG import facilities coming on line provide a significant increase in U.S. LNG import capacity. Competition for supplies in the world market, however, limits the amount of LNG that reaches U.S. markets, and U.S. LNG imports in 2035 are expected to be within 100 billion cubic feet of those received in 2007. Although U.S. LNG imports increase in the early years of the projections as additional

Figure 51. OECD North America net natural gas trade, 2007-2035 (trillion cubic feet)



liquefaction capacity comes on line, they peak at 1.5 trillion cubic feet in 2020, then decline through 2035 as the world market absorbs the additional supplies.

The continuing decline in Canada's pipeline exports is tempered by increases in production of tight gas, shale gas, and coalbed methane, along with LNG imports that allow Canada to continue exporting pipeline gas to the United States. Currently, Canada has one LNG import facility in operation at St. Johns, New Brunswick, and at least five others that are either approved or in the planning stages. LNG could play a significant role in Canada's natural gas markets by the end of the projection period, depending on the rate at which natural gas supplies can increase. The expected growth in LNG imports, particularly for Mexico and Canada, means that North America as a whole moves from a relatively self-contained natural gas market to one that is a growing participant in, and increasingly influenced by, the global natural gas market.

Natural gas trade involving OECD Europe has recently experienced some major shifts. In 2009, natural gas demand was down approximately 8 percent from 2008. At the same time, imports of LNG were up 27 percent [***25***], and imports of Russian pipeline gas were down almost 25 percent [***26***]. Continental Europe's long-term natural gas contracts have some flexibility in terms of volumes, but the prices generally are linked to lagged prices for oil products. Thus, despite the drop in demand following the global economic recession, most natural gas prices remained high, with the extremely high oil prices from 2008 continuing to figure into contract natural gas prices until the second half of 2009.

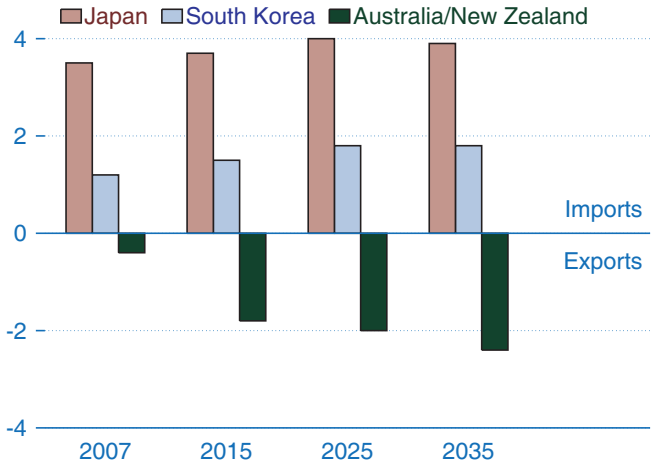
The recession and long-expected increases in global supplies of LNG combined to push European spot prices for natural gas well below those of long-term oil-linked prices, spurring those consumers who could access LNG on the spot market to increase their LNG purchases. In Europe in 2009, oil-linked prices were, at times, twice as high as LNG spot prices [***27***]. Volume flexibility in long-term contracts was inadequate to deal with the drop in demand and the increased LNG supplies. As a result, European consumers accepted less natural gas than contractual minimums and may have failed to take as much as $2.8 billion worth of natural gas under take-or-pay contracts [***28***].

Contributing to abundant European supplies in 2009 were additional LNG imports from Qatar, which brought three new liquefaction trains online, and new regasification facilities in the United Kingdom and Italy. Continued growth is expected for natural gas imports, as global LNG supplies continue to expand rapidly over the next few years and as the Medgaz pipeline from Algeria begins exporting gas to Spain in 2010 [***29***]. Furthermore, the Nord Stream pipeline from Russia and the Galsi pipeline from Algeria could push additional natural gas supplies into OECD Europe as soon as 2012 and 2014, respectively, according to planned start dates. In the *IEO2010* Reference case, net natural gas imports to OECD Europe grow on average by 1.6 percent per year from 2007 to 2035.

In OECD Asia, Japan and South Korea continue to be almost entirely dependent on LNG imports for natural gas supplies (Figure 52). The two countries continue to be major players in LNG markets (with Japan representing 41 percent of global LNG imports in 2007 and South Korea 14 percent) despite consuming relatively small amounts of natural gas on a global scale (representing 3 and 1 percent, respectively, of world consumption in 2007).

Japanese and South Korean companies are also influential in LNG markets as foundation customers[15] for greenfield Pacific liquefaction projects. For example, Japanese and South Korean companies have signed firm contracts for significant shares of the output from Russia's Sakhalin liquefaction project, which came on line in 2009, as well as from Australia's Pluto project, which is near completion, and Australia's Gorgon LNG project, which is just starting construction in 2010 [***30***]. In addition, Japanese and South Korean companies have signed either firm contracts or preliminary agreements with several projects that have not yet made final investment decisions, including the Wheatstone and Fisherman's Landing projects in Australia; an ExxonMobil-led project in Papua New Guinea; and the Kitimat project in Canada. Japanese and South Korean companies have

Figure 52. OECD Asia net natural gas trade, 2007-2035 (trillion cubic feet)



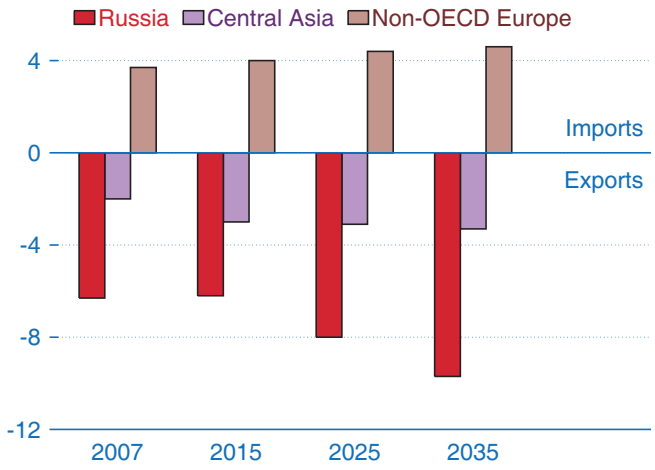
[15] A "foundation customer" is a company with a good credit rating that has signed an agreement to buy a certain amount of natural gas from a new LNG project at a certain price. By signing contracts with foundation customers, a company trying to develop a new LNG project is able to show that the project is financially viable and thus is able to obtain financing more readily and move forward with the project.

also taken small equity stakes in several of the projects, and Japan's Inpex is leading the Ichthys project in Australia, with a final investment decision expected in early 2011 [*31*].

In 2007, Australia exported 0.7 trillion cubic feet of natural gas from its two operating LNG liquefaction facilities—North West Shelf LNG, which draws gas from the Carnarvon Basin off Australia's northwest coast, and Darwin LNG, which draws gas from the Bonaparte Basin north of the Carnarvon Basin. Australia is one of the most active areas for future LNG development. Its exports of natural gas more than double by 2015, to 1.8 trillion cubic feet, in the Reference case and continue to grow throughout the projection period. Australia has two new liquefaction projects under construction in 2010, Pluto and Gorgon, both drawing gas from fields in the Carnarvon Basin. There are also at least four separate liquefaction projects in eastern Australia that aim to reach final investment decisions in 2010. All are planning to use coalbed methane from the Bowen-Surat Basin as supply, and most are planning to produce first gas around 2014 or 2015 [*32*].

Two additional liquefaction projects based off Australia's northwest coast aim for final investment decisions in 2010 or 2011. The Wheatstone project would be the fourth independent liquefaction project to draw gas from the Carnarvon Basin, and Ichthys LNG would be the first project to draw gas from the Browse Basin, which lies between the Carnarvon and Bonaparte Basins [*33*]. Several of the Australian LNG projects have plans to expand, and at least seven other separate liquefaction projects have been proposed and plan to make final investment decisions at some point after 2011. Not all of the proposed projects and expansions are assumed to go forward in the *IEO2010* Reference case, because some of them appear to be competing for the same reserves to supply their facilities.

Figure 53. Non-OECD Europe and Eurasia net natural gas trade, 2007-2035 (trillion cubic feet)



Non-OECD natural gas trade

Russia's net exports of natural gas grow from 6.3 trillion cubic feet in 2007 to 9.7 trillion cubic feet in 2035 in the reference case (Figure 53). Despite the recent dramatic declines in demand for Russian natural gas in Europe, construction of the first pipe of the new Nord Stream pipeline is moving forward. Construction on the Russian onshore sections began in 2009, and construction on the offshore portions of the first line is set to begin in April 2010, with first natural gas exports planned for the end of 2011. When complete, the first line will carry 1.0 trillion cubic feet of natural gas per year from Russia, across the Baltic Sea to Germany, bypassing eastern European transit states with which Russia has had pricing and payment disputes in the past. Russia has several other proposed export pipeline projects, including plans for a second parallel pipe on the Nord Stream pipeline by the end of 2012 and for the South Stream pipeline, which would carry natural gas across the Black Sea, bypassing Ukraine on its way to European markets [*34*].

A pipeline explosion in April 2009 forced Turkmenistan to discontinue all natural gas exports to Russia [*35*]. With demand in Russia and Europe down, Russia did not need the contracted volumes, and flows were not resumed at any point in 2009 while Russia tried to negotiate better contract prices and lower contract volumes. As a result, natural gas exports from Turkmenistan to Russia totaled only about 0.4 trillion cubic feet in 2009, just one-quarter of the approximately 1.6 trillion cubic feet traded in 2008 [*36*]. Historically, Russia has accounted for more than 85 percent of Turkmenistan's total natural gas exports. Turkmenistan was estimated to have been losing $1 billion per month during the halt in Russian imports [*37*]. The remaining 12 to 13 percent of Turkmen natural gas exports in 2007 and 2008 was delivered to Iran [*38*].

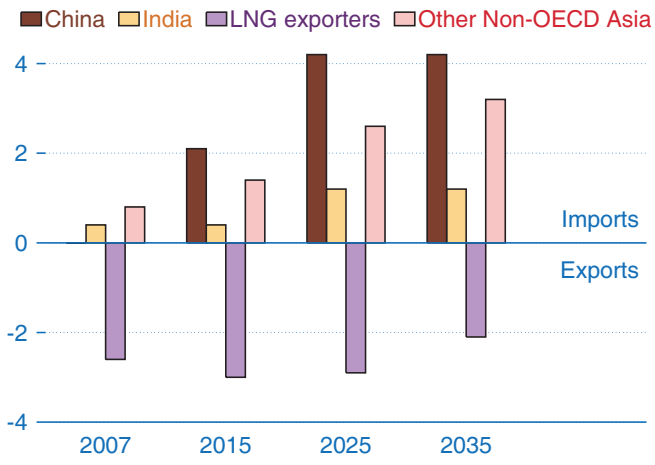
Turkmenistan has been pursuing alternative export markets and routes, with developments moving quickly since the cut-off of Russian imports in April 2009. In July 2009, Turkmenistan and Iran agreed to increase Iranian contractual natural gas volumes from 0.3 trillion cubic feet to 0.5 trillion cubic feet and to build a new cross-border pipeline. It may take some time to reach full contractual volumes, however, as actual flows have never reached the previous contractual levels since exports began in 1997 [*39*]. An existing pipeline runs from the Korpedzhe field in Turkmenistan to the town of Kurt Kui in northeastern Iran. The first phase of the new pipeline, completed in December 2009, can carry 0.2 trillion cubic feet per year from Turkmenistan's sizable Dauletabad field to a natural gas processing plant just inside Iran's northern border. In the second phase, with construction scheduled to begin in 2010 and completion expected 1 to 2 years later, the pipeline will be extended to reach more of the Iranian market.

In late 2009, Turkmenistan completed the first line of a two-line pipeline to China, which runs from the Bagtyyarlyk, Saman-Depe, and Altyn Asyr natural gas fields in Turkmenistan through Uzbekistan and Kazakhstan, before connecting with China's second West-East pipeline in Xinjiang province [***40***]. The first line has a capacity of 0.7 trillion cubic feet per year, but initial flows are likely to be much lower, because the West-East pipeline that will link it to more of China's demand centers will not be complete until 2012. By that time, the second line of the Central Asia-China pipeline should be complete, bringing total cross-border capacity to 1.4 trillion cubic feet per year [***41***]. Additional export volumes are expected to come from Turkmenistan's giant South Yolotan-Osman field and could also come from fields in Kazakhstan.

In 2005, China had no imports of natural gas and none of the infrastructure necessary to accommodate imports (Figure 54). In 2007, China's net imports amounted to just 1.8 percent of its total natural gas consumption, with 85 percent of those imports coming from a single country, Australia. At the time, China had just one operating import facility, China National Offshore Oil Corporation's LNG regasification terminal in Guangdong province, and just one long-term import contract with Australia. In the *IEO2010* Reference case, China meets 43 percent of its consumption in 2035 with imported natural gas. To meet its future import demands, China is actively pursuing multiple potential sources for natural gas imports.

At the end of 2009, China had three LNG import terminals in operation, two under construction, and several more proposed or in various stages of development. At that time, China was importing natural gas under long-term contract from four different countries—Australia, Indonesia, Malaysia, and Qatar—with no single country signed up to provide more than 37 percent of the total contracted volume. Chinese companies have signed contracts to increase imports from Australia, Qatar, and Malaysia, but Australia is likely to remain China's main LNG supplier because of its geographic proximity and its large and growing list of upcoming LNG export projects. Chinese companies have also signed agreements to bring in LNG from Iran and Papua New Guinea. Although there has been little progress on Iran's LNG projects, those in Papua New Guinea are progressing quickly and could be delivering natural gas by 2015.

Figure 54. Non-OECD Asia net natural gas trade, 2007-2035 (trillion cubic feet)



At the same time that China is pursuing multiple sources for LNG imports, it is pursuing multiple sources for pipeline natural gas imports. As noted above, the first line of China's first natural gas import pipeline, completed in late 2009, will transport supplies from Turkmenistan and Kazakhstan. Another new pipeline from Myanmar, scheduled for completion in 2013, will carry 0.4 trillion cubic feet of natural gas per year from Myanmar's offshore fields in the Bay of Bengal to Kunming in China's Yunnan province [***42***].

China and Russia continue to discuss future natural gas pipeline connections between the two countries. They signed an agreement in 2006 stating that natural gas deliveries should begin by 2011, and then in 2009 they signed another agreement stating that deliveries should begin by 2014 or 2015. Both agreements envision two separate pipelines: an eastern line and a western line. No agreement has been reached with regard to prices and volumes, and the lack of agreement on prices has been the main impediment to the project's progress. The 2006 agreement suggested volumes of 1.1 to 1.4 trillion cubic feet per year of natural gas. In the 2009 agreement, however, the volumes under discussion grew to 2.5 to 2.8 trillion cubic feet per year [***43***].

In 2007, India imported 0.4 trillion cubic feet of natural gas through its two operating LNG regasification terminals, accounting for about 24 percent of the natural gas consumed in India that year. In the *IEO2010* Reference case, India's imports as a share of its total natural gas consumption fall to 14 percent in 2015, as new production from the Krishna Godavari Basin comes on line. In the long term, however, demand growth outpaces production growth: consumption grows by 1.8 percent per year from 2015 to 2035, while domestic production grows by 1.0 percent per year. Accordingly, India is expected to continue expanding its LNG import infrastructure.

Although India has discussed pipeline projects with Iran, Central Asia, and Myanmar in the past, there are significant barriers to those plans, including politics, geography, and costs. Two LNG regasification terminals were operating in India in 2007, at Dahej and Hazira. In addition, a third terminal at Dabhol is to be brought partially on line in 2010, and a fourth, under construction at Kochi, is expected to come on line in 2012. Numerous

other facilities have been proposed, but progress has been hindered, first by difficulties in finding long-term supplies at acceptable prices and more recently by a wait-and-see attitude in the Indian natural gas industry as participants wait to see how quickly production from the Krishna Godavari field will be absorbed.

In 2007, three countries in non-OECD Asia—Indonesia, Malaysia, and Brunei—had LNG export facilities. In addition, Papua New Guinea is preparing to become an LNG exporter. There are several LNG liquefaction projects proposed for Papua New Guinea. At the end of 2009, a project led by ExxonMobil became the first to reach a final investment decision [***44***]. Construction is set to begin in 2010, and first gas is expected in 2014. Two liquefaction trains are planned, with total annual exports of 0.3 trillion cubic feet of natural gas. In the mid-term, growth in exports from Papua New Guinea and Indonesia's Tangguh LNG, which came on line in 2009, increases net exports from these Asian producers as a region. Production from the Arun and Bontang LNG facilities currently in operation in Indonesia, however, is expected to continue declining [***45***]. Indonesia has plans to build at least one LNG regasification facility on its own shores, which would further decrease net exports from the region. In the Reference case net exports from these four countries, as a region, decline from 2.6 trillion cubic feet in 2007 to 2.1 trillion cubic feet in 2035.

Qatar is the world's largest LNG exporter. Its total LNG exports grew by 17.5 percent per year on average from 2000 to 2007 and by another 30.6 percent from 2007 to 2008. In the *IEO2010* Reference case, Qatar's LNG exports grow throughout the projection period. Most of the growth is projected for the 2007-2015 period, as Qatar brings on line six mega-sized liquefaction trains. Each train has the capacity to produce the equivalent of 0.36 trillion cubic feet of natural gas per year for export. The first of the six liquefaction trains came on line in 2009, and the last is scheduled for completion in 2011.

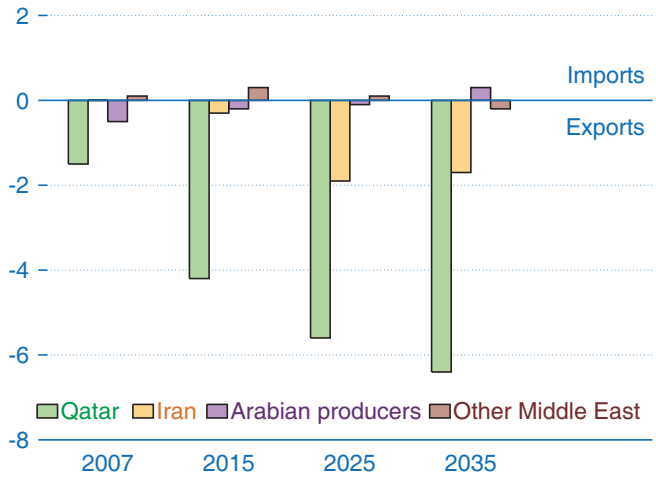
Qatar's natural gas exports grow by an estimated average of 13.5 percent per year from 2007 to 2015 in the Reference case (Figure 55), then slow to an average increase of just 2.1 percent per year after 2015, when projects currently under construction will have been completed. Because of a current moratorium on further development from the North Field, no new projects are being initiated. The moratorium was put in place in 2005 in order to give Qatar a chance to assess the effect of the ongoing ramp-up in production on the North Field before it commits to further production increases. Originally set to expire in 2008, the moratorium has recently been extended to 2014 [***46***].

If Qatar decides to lift the moratorium on North Field development in 2014, its stated development priority is to ensure that it can meet long-term domestic natural gas needs for power generation, water desalination, and local industry. Only after those needs are met will it consider further increases in exports, and any increases are expected to come primarily from optimization of current facilities [***47***]. The six mega-trains currently being brought on line are the largest liquefaction trains in the world, and they employ several new technologies. Although the new technologies have contributed to the sometimes problematic commissioning process, they also are likely to provide opportunities for increasing operating capacity through process optimization and "de-bottlenecking" operations [***48***].

Iran, which shares the North Field/South Pars Field with Qatar, has the world's second-largest natural gas reserves (behind Russia but ahead of Qatar). Despite its abundant reserves, Iran was a net importer of natural gas in 2007, importing slightly more from Turkmenistan than it exported to Turkey. Although its first LNG export plant is under construction, Iran is without international partners and without any obvious source for obtaining the actual liquefaction technology, which it currently does not possess domestically [***49***]. Other export projects continue to be discussed, but as a result of international and internal politics there has been little progress on most projects. In the Reference case, Iran becomes a net exporter of natural gas with a combination of LNG and pipelines through Turkey to Europe, but it does not become a major exporter, because domestic demand and demand for reinjected gas limit its exports despite its massive resources.

Yemen began production at its first LNG export plant in 2009. At full capacity, the plant is expected to export the equivalent of 0.3 trillion cubic feet of natural gas per year. Two additional countries in the Middle East—Oman and the United Arab Emirates (UAE)—also export LNG. Both countries also import natural gas via pipeline from Qatar, and while the UAE maintained a slim margin as a net exporter in 2007, preliminary data for 2008 indicate that it became a net importer. The

Figure 55. Middle East net natural gas trade, 2007-2035 (trillion cubic feet)



IEO2010 Reference case projects a similar trend for the Arabian Peninsula producers, which include Kuwait, Oman, UAE, and Yemen. As a group, they exported a total of 0.5 trillion cubic feet of natural gas in 2007; but by 2030 the region becomes a net importer of natural gas, and in 2035 its net imports total 0.3 trillion cubic feet.

In addition to pipeline natural gas from neighboring countries, countries in the Arabian Peninsula are beginning to import small volumes of LNG. In 2010, the emirate of Dubai in the UAE will begin importing LNG to meet peak summer natural gas demand via a floating LNG regasification terminal. A similar facility allowed Kuwait to begin importing natural gas in the summer of 2009, also to meet seasonal peak demand [***50***].

In 2007, North Africa exported almost 3 trillion cubic feet of natural gas (Figure 56), or 56 percent of its production, with about one-half of the exports coming from Algeria, Egypt, and Libya via pipelines to Spain, Italy, and parts of the Middle East. The remainder was exported as LNG from liquefaction facilities in Algeria, Egypt, and Libya.

Algeria is in the process of expanding its natural gas export capacity both by pipeline and from LNG terminals. The Medgaz pipeline from Algeria to Spain is expected to come on line in mid-2010, with sufficient capacity to carry 0.3 trillion cubic feet of natural gas per year. Two liquefaction projects are also progressing in Algeria: the Gassi Touil project and a new liquefaction train at the existing Skikda export facility [***51***]. Together they are expected to increase Algeria's LNG export capacity by 0.4 trillion cubic feet per year by 2013. In addition, the Galsi pipeline from Algeria to Italy is planning to make a final investment decision before the end of 2010 and to initiate gas flow on a 0.4 trillion cubic foot per year pipeline by 2014 [***52***].

Any additional major expansions of export capacity from North Africa are projected to be dependent on the Trans-Sahara natural gas pipeline. The pipeline, if built, would stretch 2,800 miles to bring natural gas from Nigeria, across Niger, and connecting in Algeria to export pipelines to Europe. The Trans-Sahara pipeline was given the official go-ahead in 2009, having been declared economically and technically feasible, and 2015 was set as the official targeted start date. However, the project still faces significant security issues and has not yet secured financing.

As recently as 2007, South America was an almost entirely self-contained market for natural gas, with no means of importing gas to the continent (Figure 57) and only one avenue for exporting it: the LNG liquefaction facilities on the island of Trinidad and Tobago. Since then, natural gas in South America has become increasingly globalized. In late 2008, Brazil opened its first floating LNG storage and regasification facility, the Pecem terminal in the country's northeast. A second floating LNG regasification unit followed in 2009 at the Guanabara Bay terminal in the southeast [***53***]. Brazil also has proposals to employ floating LNG liquefaction at its offshore subsalt natural gas fields. The primary goal of the offshore liquefaction project is to bring gas to Brazil's own regasification terminals, exporting it only when there is excess supply.

In the *IEO2010* Reference case, Central and South America's northern natural gas producers (Colombia, Ecuador, Trinidad and Tobago, and Venezuela) account for most of the region's net exports, which increase from 0.7 trillion cubic feet in 2007 to 1.8 trillion cubic feet in 2035. The rest of South America—mainly, Bolivia, Argentina, Chile, and Peru—was a net natural gas exporting region in 2007, with 0.4 trillion cubic feet of natural gas exported from Bolivia to Brazil. However, in the Reference case, increases in Brazil's domestic production diminish the need for Bolivian supplies. In addition, LNG imports to Argentina, Chile, and possibly Uruguay more than offset exports from Peru, where an LNG

Figure 56. Africa net natural gas trade, 2007-2035 (trillion cubic feet)

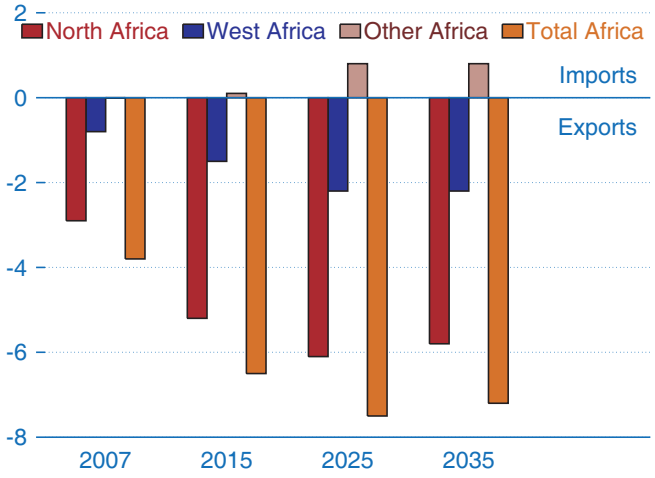
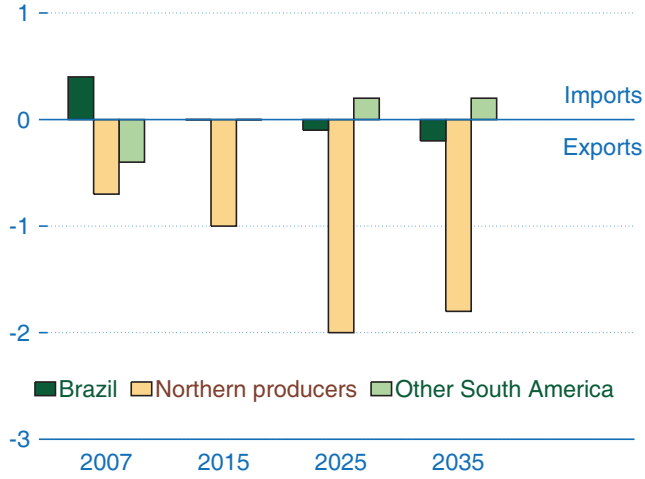


Figure 57. Non-OECD Central and South America net natural gas trade, 2007-2035 (trillion cubic feet)



project is likely to come on line in 2011 with an export capacity of 0.2 trillion cubic feet per year.

As of January 2010, there were two LNG import facilities operating in South America outside Brazil. The first, in Argentina, came on line in 2008 with a nominal capacity of 0.1 trillion cubic feet per year. The second, at Quintero, Chile, opened in 2009 and brought the region's total import capacity to 0.3 trillion cubic feet [*54*]. Chile's second regasification facility is currently under construction at Mejillones, and additional import capacity has been proposed for Uruguay and Argentina. There is no additional export capacity proposed for the region.

World natural gas reserves

Almost three-quarters of the world's natural gas reserves are located in the Middle East and Eurasia (Figure 58). Russia, Iran, and Qatar together accounted for about 55 percent of the world's natural gas reserves as of January 1, 2010 (Table 7).

Historically, world natural gas reserves have generally trended upward (Figure 59). As of January 1, 2010, the world's total proved natural gas reserves, as reported by *Oil & Gas Journal*,[16] were estimated at 6,609 trillion cubic feet—355 trillion cubic feet (6 percent) higher than the estimate of 6,254 trillion cubic feet for 2009 [*55*].

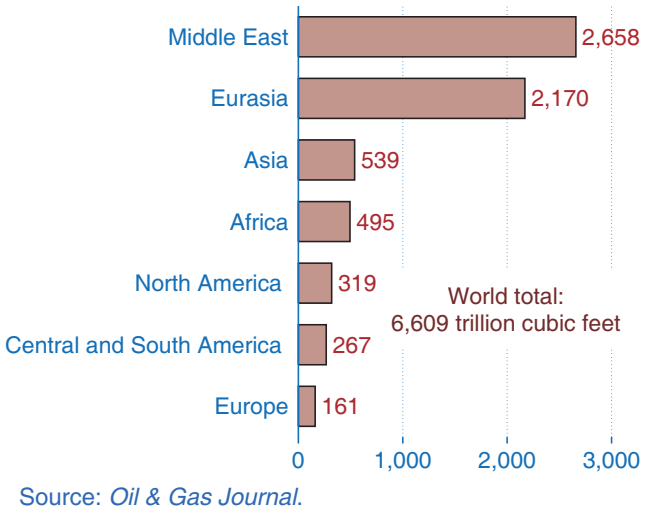
The largest increases in reported natural gas reserves in 2010 were for Turkmenistan and Australia. In Turkmenistan, natural gas reserves are now estimated at

Table 7. World natural gas reserves by country as of January 1, 2010

Country	Reserves (trillion cubic feet)	Percent of world total
World	**6,609**	**100.0**
Top 20 Countries	**6,003**	**90.8**
Russia	1,680	25.4
Iran	1,046	15.8
Qatar	899	13.6
Turkmenistan	265	4.0
Saudi Arabia	263	4.0
United States	245	3.7
United Arab Emirates	210	3.2
Nigeria	185	2.8
Venezuela	176	2.7
Algeria	159	2.4
Iraq	112	1.7
Australia	110	1.7
China	107	1.6
Indonesia	106	1.6
Kazakhstan	85	1.3
Malaysia	83	1.3
Norway	82	1.2
Uzbekistan	65	1.0
Kuwait	63	1.0
Canada	62	0.9
Rest of World	**606**	**9.2**

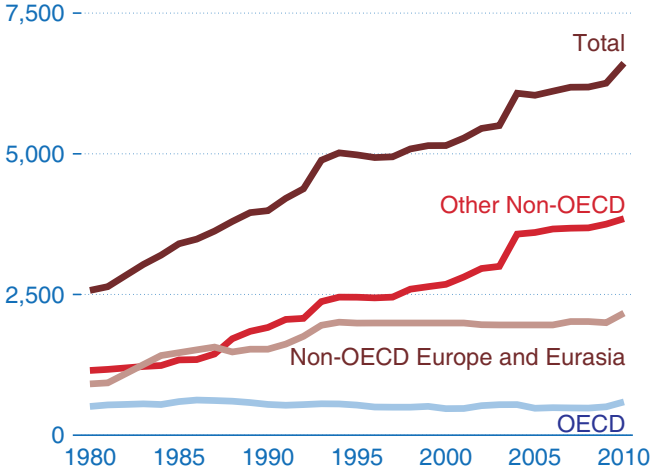
Source: *Oil & Gas Journal*.

Figure 58. World natural gas reserves by geographic region as of January 1, 2010 (trillion cubic feet)



Source: *Oil & Gas Journal*.

Figure 59. World natural gas reserves by region, 1980-2010 (trillion cubic feet)



Sources: *International Petroleum Encyclopedia* and *Oil & Gas Journal*.

[16] Proved reserves, as reported by the *Oil & Gas Journal*, are estimated quantities that can be recovered under present technology and prices. Natural gas reserves reported by the *Oil & Gas Journal* are compiled from voluntary survey responses and do not always reflect the most recent changes. U.S. proved reserves of natural gas are reported by the U.S. Energy Information Administration and are defined as the estimated quantities of natural gas reserves as of December 31, 2009, which analysis of geological and engineering data demonstrates with reasonable certainty to be recoverable in future years from known reservoirs under existing economic and operating conditions. Significant natural gas discoveries made in 2009 are not likely to be reflected in the reported reserves.

265 trillion cubic feet, an increase of 171 trillion cubic feet (182 percent) over its 2009 proved reserves, following reappraisals of the giant South Yolotan-Osman gas field [*56*]. The reserves in the South Yolotan-Osman field are now estimated at between 141 and 494 trillion cubic feet, making it the fifth-largest natural gas field in the world [*57*].

In Australia, reserve estimates were revised upward by 80 trillion cubic feet, from 30 trillion cubic feet to 110 trillion cubic feet. The increase is attributed to the reporting of reserves under the Australian government's McKelvey reporting system rather than the traditional petroleum industry classification.[17] Smaller but still substantial increases were reported for Iran and China. Iran added an estimated 54 trillion cubic feet, a 5-percent increase over 2009 reserves, and China added 27 trillion cubic feet, a 34-percent increase. In the Middle East, Qatar and Saudi Arabia added 7 trillion cubic feet and 5 trillion cubic feet, respectively. In North America, the United States and Canada added a combined 11 trillion cubic feet. In South America, Venezuela added 5 trillion cubic feet. Declines in natural gas reserves were reported for Trinidad and Tobago (a decrease of 3 trillion cubic feet, or 18 percent) and the United Kingdom (a decrease of almost 2 trillion cubic feet, or 15 percent).

Despite high rates of increase in natural gas consumption, particularly over the past decade, the above increases in reserves imply that reserves-to-production ratios for most regions have remained substantial. Worldwide, the reserves-to-production ratio is estimated at 60 years [*58*]. By region, the highest ratios are about 46 years for Central and South America, 72 years for Russia, 68 years for Africa, and more than 100 years for the Middle East.

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[17] Geosciences Australia reports petroleum resources under two classification systems: the traditional industry classification and the McKelvey classification. For further information, see web site www.ga.gov.au/oceans/pub_reports.jsp. Use of different reporting systems underscores the inherent uncertainty associated with the reported world reserves estimates. Definitions may vary among country reports, with potentially substantial impacts on the reported levels of reserves.

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